Examine the Impact of STEM Education on the Cognitive Advancement of Middle School Students

SHORT SYNOPSIS

Submitted in partial fulfilment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

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by

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19/PhD/061

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Certificate

I hereby declare that the short synopsis "Examine the Impact of STEM Education on the Cognitive Advancement of Middle School Students" being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Management under School of Leadership and Management of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2019-2020. It is a bona fide record of original work carried out under the supervision of Dr. Sonal Pathak and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

Cognitive Development derives how individuals think, explore and sort out the things. It is the progress of information, limits, essential thinking and mindsets, which assist individual with considering and understanding their generally natural components. Passionate prosperity is central for insightful new turn of events. Like the sort of information being found about the working of memory, teaching best for innovativeness, and the way individuals learn. Science, Technology, Engineering and Math (STEM) is latest and testing change of preparing which helps in making 21st century limits and innovative thinking. The reason for this investigation is to assess the causal impact of the STEM (Science, Technology Engineering, Mathematics) drive on middle school students' psychological results. Middle school is a significant momentary time during students' lives. During middle school, students are all more truly thinking about their scholastic and non-scholarly interests, just as future school and vocation plans. The greater part of the STEM training research centres around rudimentary or secondary schools, and hardly any investigations centre explicitly around the impact of a STEM informative structure on the results of middle school students. Given growing interest for versatile geniuses prepared in the STEM fields it is significant that we understand that STEM drive have effective impact on middle school level student as at this stage the cognitive development is high and this can be done with proper training and practical exposure of concepts rather than giving them habit of cramming just to clear the exam. STEM will be a quality tool to flourish the capacity of young minds and at this level, they adapt information which would be long lasting throughout their life so this requirement can be fulfil through STEM Education. This shows that there is much scope in STEM which boosts cognitive development and assists students with making academic and higher request thinking abilities.

Keywords: Cognitive Skills, Learning, STEM, Thinking Ability, Assessment, Creativity, Interdisciplinary STEM.

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1. INTRODUCTION

1.1 Cognitive Development

Cognitive development refers to the child's ability to think out of the box. The purpose is to create the spark in the child's mind to learn the innovative way of learning. Cognitive development is the necessity of today's era. Cognitive development covers every one of the progressions that outcome from the wonders like seeing, recalling, thinking, choosing, and critical thinking in the psychological cycle. With new innovations that permit researchers to notice the mind capacities as they happen, it has been acquiring experiences into how the mind learns, absorbs, thinks and recollects. Piaget who is the author of the hypothesis of intellectual improvement guarantees that the way toward comprehension and finding begins from birth and proceeds long lasting alongside the learning interaction for kids. Piaget in his investigations of clarifying psychological cycles likewise requests that kids don't take information as it were from grown-ups rather, they build up their own particular manner of understanding the world. So, he accepts that kids are not inactive perceivers of the world; then again, they are very dynamic in acquiring information. Piaget expressed that intellectual advancement happens in four periods and as the time frames progress, youngsters' seeing and critical thinking capacities show improvements subjectively. Psychological improvement as indicated by Piaget's learning hypothesis has four phases. They are; sensorimotor (0-2 age), pre-activity (2-7 age), solid tasks (7-11 age) and conceptual activities (11 and over age). Piaget guarantees that an individual couldn't skirt one phase and move to another. Plus, capacities that tag along with each intellectual improvement stage could show contrasts as per circumstances like the existence that a youngster has, natural components, and availability level.

1.2 STEM Based Education

STEM education is a progressive advance in the schooling business. In basic words, STEM learning depends on showing significant abilities to the youthful trend-setters in the four principal areas of – Science, Technology, Engineering and Mathematics. STEM training in India is tied in with learning by doing. With the assistance of entertaining themselves with

STEM learning-based exercises, numerous students will get an opportunity to find their actual potential and they likewise find another technique for learning an idea in a fun and intelligent way. It prepares students future by showing them abilities that will be popular in the impending years. As per the Public Science Establishment, it is an expectation that 80% of future positions will require the possibility to have some type of STEM abilities.

1.3 Importance of STEM Education in India

Indeed, even the public authority comprehends the significance of STEM training and the estimation of advancement among youthful personalities along these lines it has set up the Atal Innovation Mission at NITI Aayog which upholds the foundation of Atal Tinkering Labs in qualified schools across India. This ATL lab comprises of different present day imaginative apparatuses and gear like DIY units, 3D printer, mechanical and gadgets hardware utilizing which students do different STEM learning exercises that go far past their reading material educational program. For a school to set up the Atal Tinkering lab, it should fulfil a few rules which are set up by NITI Aayog.

There are numerous brilliant advantages offered by STEM schooling in India some of them are given down underneath.

a) It discloses to the students how they can become problem solver by utilizing the information which they procure from STEM learning.
b) It shows different kinds of valuable imaginative abilities to students like computational reasoning, critical thinking abilities, Inventive reasoning, sensible thinking, better dynamic, and great perception power.

STEM instruction in India is the truly necessary transformation in the schooling business that can possibly reshape the youngster's future. There are two fundamental techniques for Learning- Repetition Learning and STEM learning. The main strategy for learning is the customary Repetition realizing which depends on retaining the data dependent on reiteration. Basic Instances of these incorporate remembering the increase tables, intermittent table, and so forth Despite the fact that Repetition learning is drilled all through the country for quite a

long time the disadvantage of this kind of conventional learning is that the students don't improve comprehension of the subject.

1.4 The Relationship: Cognitive Development, Assessment and Interdisciplinary STEM

Learning is the point of convergence of planning and recollects changes for students' information, aptitudes and comprehension. Memory is the restriction of data through cycles controlled by the mind. It joins brief memory and working memory that have a bound limitation of dealing with data and a restricted period of time other than. The fairly long memory has the best ability to store data for quite a while. The current second and working memory from time-to-time cause dismissing, when impedance happens. The memory is viewed as the connection between the learning and the appraisal, where the students do the demonstrations of data in the working memory to move it to the to some degree long memory, by then it will overall be recovered again while contemplating students' abilities and information. The Figure 1 shows the association between learning categories and assessment categories.

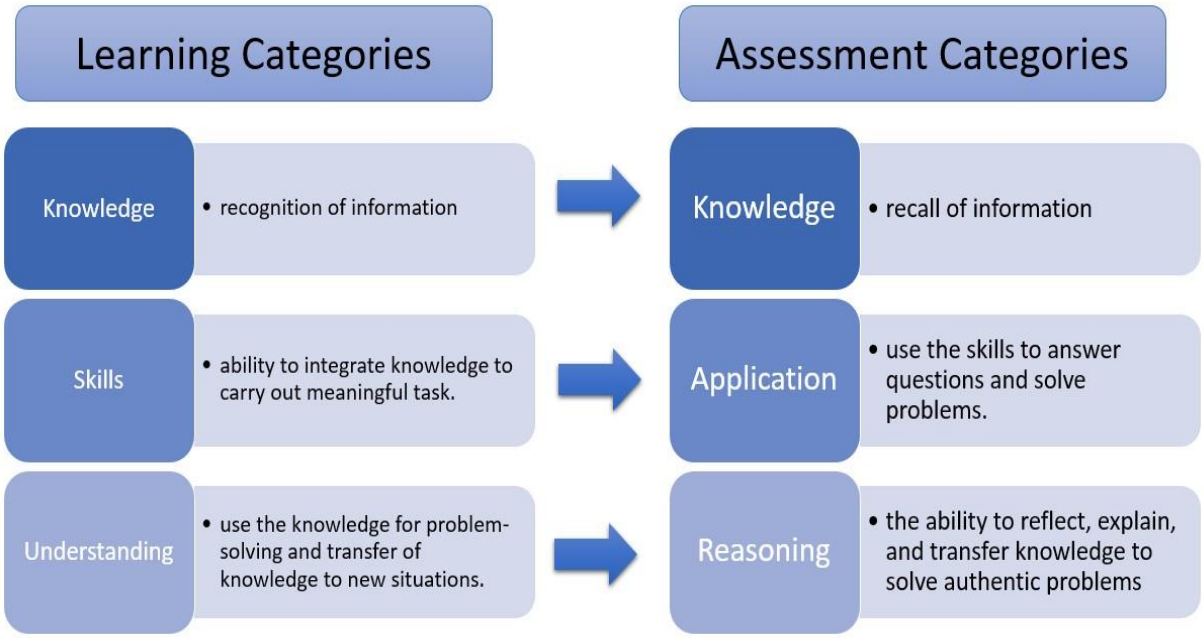
Learning Categories
Assessment Categories
Knowledge
• recognition of information
Knowledge
• recall of information
Skills
• ability to integrate knowledge to carry out meaningful task.
Application
• use the skills to answer questions and solve problems.
Understanding
• use the knowledge for problem-solving and transfer of knowledge to new situations.
Reasoning
• the ability to reflect, explain, and transfer knowledge to solve authentic problems

Figure 1: The relation between the learning categories and assessment categories

Source: Areej ElSayary, Journal for Researching Education Practice and Theory (JREPT), 2018

1.5 Current Status of STEM

Various countries have supported their states, areas, and schools to do the switch subsequent to understanding the conceivable outcomes of a STEM program. With leap forwards in science and innovation like mechanical technology, IoT, and different fields, there will be an interest for IT abilities across industries. However, as the abilities fundamental for these positions become further developed after some time, work searchers should proceed to upskill to stay significant in the business. With Atal Tinkering Labs, the Indian government has helped more than 3000 schools prepare themselves and help students acquire active involvement with cutting edge innovations as a component of the 'Skill India' drive (ATL). Robotics is an intriguing method to incorporate STEM instruction into schools, and it is one of the essential components of STEM preparing. Have a look at the trending companies that are making powerful STEM schooling conceivable across India:

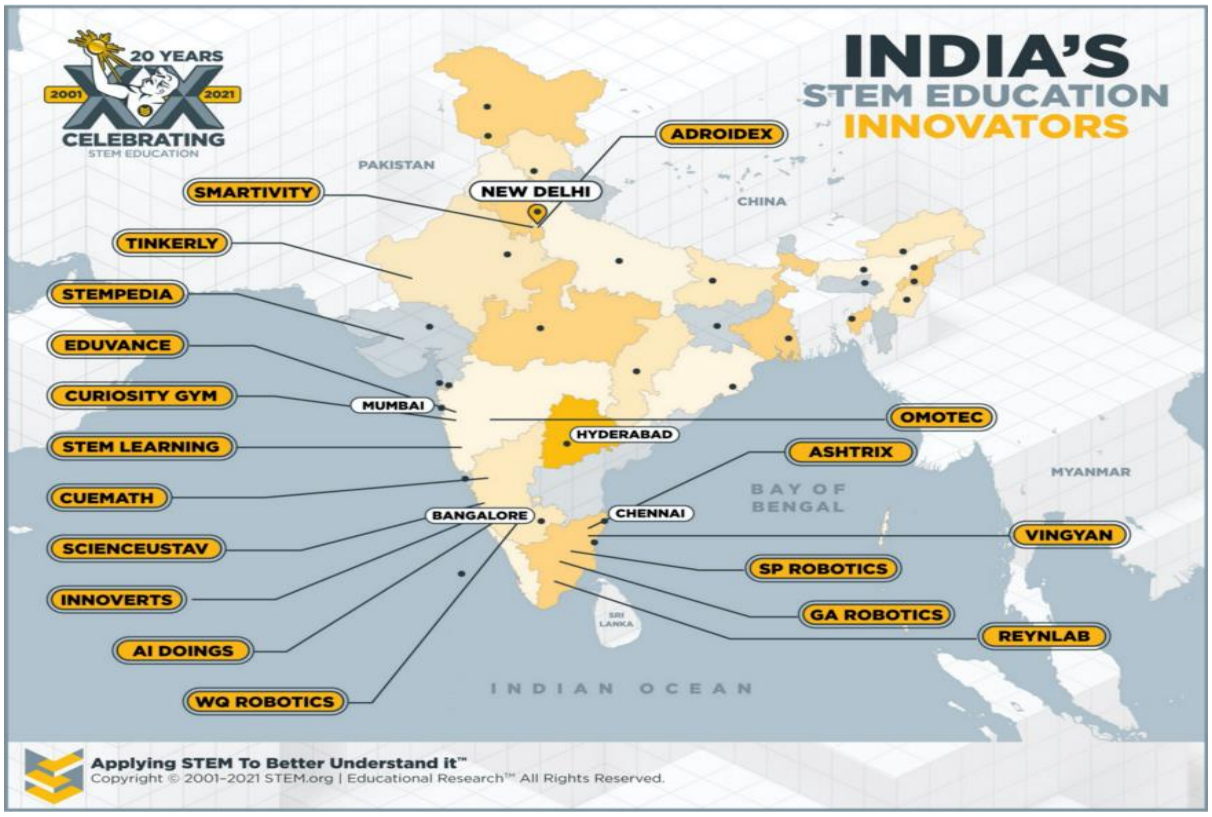

Figure 2 showing the STEM organisations

Source: Andrew B. Raupp STEM.org Education Research™ / India STEM Inventory Map Q4 2020 v1.4

Percentage of STEM women graduates in India higher compared to US, UK:

In India, the percentage of female graduates in Science, Technology, Engineering, and Mathematics (STEM) fields at the tertiary level surpasses that of developed countries like the US, UK, Germany, and France. In 2016, while India had a female STEM graduate rate of 42.72 percent, the figures for the United States, Germany, the United Kingdom, France, and Canada stood at 33.99 percent, 27.14 percent, 38.10 percent, 31.81 percent, and 31.43 percent, respectively. This trend continued in 2017 and 2018, with India's female STEM graduates comprising 43.93 percent and 42.73 percent, respectively.

Addressing concerns about the gender distribution within STEM fields over the past three years, data from the All India Survey on Higher Education (AISHE) revealed that while the number of male graduates decreased from 12.48 lakh in 2017-18 to 11.88 lakh in 2019-20, the number of female graduates increased from 10 lakh to 10.56 lakh during the same period.

2. LITERATURE REVIEW

There are not many researchers in India who have dealt with the investigation of STEM Education in creating intellectual capacities at middle school level. In this piece of study, we have had the option to outline a few areas in which exploration has been done and this can illuminate further enquiry into the effect regarding STEM training. We were looking to set up proof for the effect of intercessions on student learning in credible classroom settings. Despite the fact that concentrates on STEM surveys, there were just general insights regarding the actual practices of the study, for example, evaluation strategy, a theoretical system to clarify how students foster their psychological and metacognitive reasoning, redundancy learning.

2.1 Appraisal, Motivation, Evaluation & Innovativeness

Greetings (2017) has pointed that the examination as learning helps in changing students' penchants for mind what's more, changes their impression of audit the world. This is because students are busy with genuine issues that require the use of composed data and grant them to envision diverse possible game plans, watch and reflect during the work cycle, and be accessible to new proposition and assumptions.

Almqvist, Vinage, Vakeva and Zanden (2017) uncovered that the central inspiration driving evaluation as learning is acceptability. Most evaluations in the schools propose to state one single reaction for an issue. This is known as simultaneous thinking, which is to focus in on one response for deal with an issue. It is principal to study students' ability in tracking down a couple of answers for a comparable issue. This is called different thinking and requires high coordinated efforts from students to ask, conceptualize and inspiration to find elective responses for an issue. These exercises are done in the functioning memory where the students use and apply their capacities in the new information to find courses of action and a short time later this development to stay in the somewhat long memory where there are demeanours of aptitudes they have gotten.

Drake and Reid (2017) In addition, assessments set a test for teachers where the remarkable spotlight was on the chance of the melded information and less center given to the manner by which students are explored.

Beghetto (2015) Instructors in schools feel the pressing variable between making students' inventiveness and setting them up to perform well in the standardized appraisals. STEM heading has been taken as a blueprint to explain how students can get the 21st century aptitudes and how creativity has been joined into the learning cycle.

ElSayary, Forawi and Mansour (2015) analysed that a hypothetical framework has been made to explain how students develop their mental and metacognitive thinking.

Heddy and Pugh (2015) discovered an immense issue which has arisen, the strain that teachers feel between empowering significant and amazing learning and the duty of worldwide evaluations that compel them to instruct toward tests. The consideration on inside and worldwide examinations reduces the proportion of time open for planning combination inside teaching and learning.

Weinberg and Yu (2013) in their investigation, expressed that advanced mechanics makes an exceptional learning climate by giving physical epitome of calculation; students get solid, instinctive input from truly encountering their work. In mechanical technology classes, as the creators expressed, students investigate, make theories about how things work, and lead investigations to approve their convictions and suspicions. Robots are helpful guides for

showing arithmetic and physical science; they can be utilized in homerooms for clarifying troublesome ideas, as they catch the creative mind of numerous more youthful individuals. Besides, the attachment and-play normal for instructive robots, similar to LEGO Mindstorms RCX, makes it simpler to learn complex designing subjects without having essential information.

Long (2011) described learning into three classes: data, aptitudes, and understanding, while evaluation spaces are assigned: data, application, and thinking. Suitably, understanding the relationship among learning and examination by using the memory cycle will be discussed to grasp the best technique to fill the opening which has occurred.

The Baker (2008) additionally discovered educator and student mentalities were a moderate to slight issue. Educators should have confidence in and effectively utilize a technique for instructing before students will purchase in to it.

Puncher D. (2008) found that educators should feel great with instructional techniques and acknowledge them before they will utilize them reliably. The educator 's demeanor straightforwardly influences students' perspectives, as does students' inclinations and sensations of connectedness and pertinence of the material. 2010 Western AAAE Research Conference Proceedings To expect all the posterity of a comparative age to acquire from a comparative instructive program looks like expecting that all the young people wear a comparable size of pieces of clothing. Students are assorted in the way they learn. They are sensation, visual, hear-capable and material students. Educators should know: how information is best seen; the sort of information enjoyed; how students figure out the information; how information is readied; and the headway of students' agreement.

2.2 STEM as a way of Revolutionizing Education

Pagar R. (2018) emphasised that the STEM instruction in India is the truly necessary transformation in the schooling business that can possibly reshape the youngster's future. There are two fundamental techniques for learning-Repetition Learning and STEM learning. The main strategy for learning is the customary Repetition realizing which depends on retaining the data dependent on reiteration. Basic Instances of these incorporate remembering the increase tables, intermittent table, and so forth Despite the fact that Repetition learning is

drilled all through the country for quite a long time the disadvantage of this kind of conventional learning is that the students don't improve comprehension of the subject.

Buchholz K. (2020) dissected that India, with a still high part of pretty much 32% of students picking STEM, made the most graduated class through and through with for all intents and purposes 2.7 million of each 2018, as shown by the data.

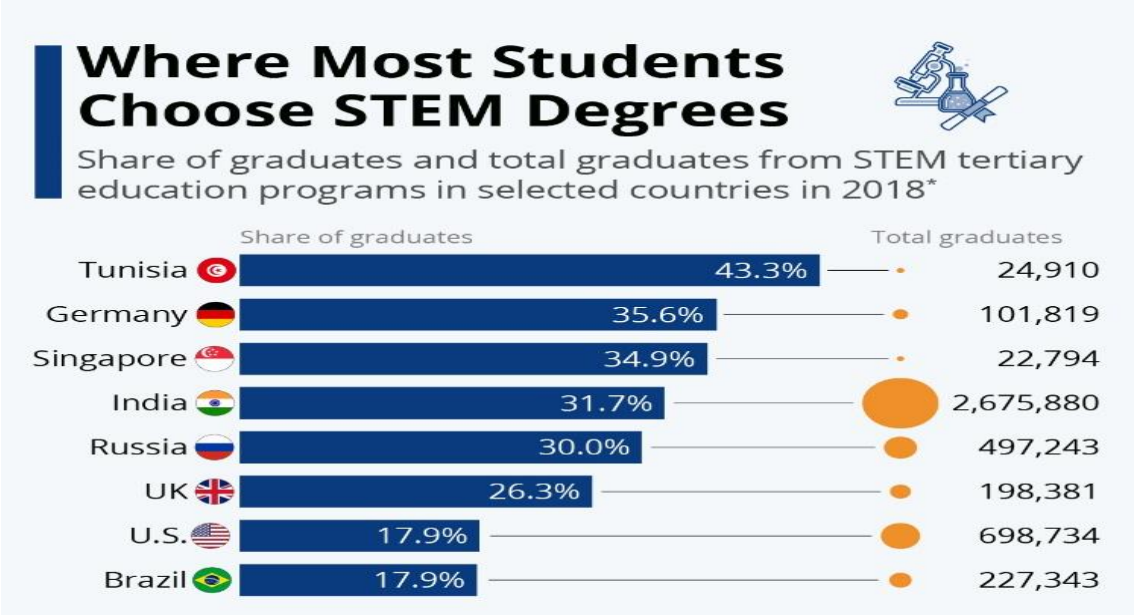
Where Most Students Choose STEM Degrees
Share of graduates and total graduates from STEM tertiary education programs in selected countries in 2018*
Share of graduates
Total graduates
Tunisia 43.3% 24,910
Germany 35.6% 101,819
Singapore 34.9% 22,794
India 31.7% 2,675,880
Russia 30.0% 497,243
UK 26.3% 198,381
U.S. 17.9% 698,734
Brazil 17.9% 227,343

Figure 2: The above chart depicts the number of total STEM graduates and there share in selected countries of year 2018.

Source: UNESCO Institute of Statistics published in Tertiary education in Asia Pacific, 2020

2.3 STEM Education Challenges in India

Awasthi (2020) analysed that there is a misguided judgment about STEM instruction among the instructors that it will redirect the students from their normal examinations and they won't focus on their course reading educational plan in that specified measure of time. In any case, this isn't accurate. STEM learning can go inseparably with the scholastic educational plan and develops the youthful pioneers of things to come of innovation.

It has been discovered that the greatest test associated with the execution of STEM training is to plan framework, educational program and to furnish youngsters with the best direction and backing. Another test could be financing. Schools require cash for development of Maker

spaces, DIY (Do it Yourself), and best PCs, which are a portion of the fundamental parts of the STEM training. Putting resources into teaching the environment about the requirement for such projects is one of the methods of beating these restrictions (**STEMpedia (2018)**

India faces another challenge in enhancing STEM education beyond its current state, which is the lack of confidence among individuals in its efficacy. Many educators still believe that introducing STEM could lead to students getting distracted from their studies, thus hindering their ability to complete the prescribed curriculum within the allotted time. The most effective approach to tackle this issue is by raising awareness and altering their beliefs through demonstrating the positive outcomes of introducing students to STEM learning methods.

2.4 Gaps in the Existing Study

1. In India, STEM organization are increasing. The main role and core activities of STEM organization are knowledge creation, product development, innovation. The essential component is to provide STEM services to school but STEM organisations do find challenge in providing best services in terms of qualified teachers, equipment, infrastructure. These challenges need to be explored.
2. There is a challenge which is a need to pay heed on that only Few Indian Researchers have emphasised on cognitive development through STEM.
3. Many schools are opting STEM but analysis of the success rate of STEM based learning in Indian perspective is need to be explored.
4. Teachers are hired from science & engineering background to teach STEM students but for better efficiency & effectiveness there is a need of an hour for STEM degree in India or STEM certified courses. This is a challenge which need to be explored.
5. STEM activities are being taught in schools and even worksheets, assignments are given for revision and exploration but analysis of a student cognitive ability after learning something from STEM needs to be explored.
6. The detailed practices adopted by STEM organisations for STEM implementation in schools have not been systematically mapped out. Many authors have written about various skills and abilities which get enhanced by STEM but few have explored how to modify existing processes and create awareness about STEM importance.

3. DESCRIPTION OF BROAD AREA

STEM(Science, Technology, Engineering and Mathematics) has a successful way of involving students in high level thinking, and further develop critical thinking abilities by putting science and mathematics with regards to technology and engineering. The point of STEM-based learning is to foster school graduates' abilities on science, technology, engineering, and math. Individuals instructed with STEM-based learning are relied upon to have effective & efficient skills that are offset with delicate abilities, in light of the fact that the learning system is done by dynamic learning & cognitive strategies that incorporate communication, creativity, logical reasoning, leadership, problem solving and others.

STEM is an area which is expanding globally focussing on Skill development among young students. Analysis of STEM education on Cognitive development, importance & to discover how educational organizations are adopting out 'STEM classes to build a skilled India is a mandate nowadays. As the world's second most populous nation, India possesses immense potential and a rich cultural heritage. However, to fully harness the benefits of STEM education, our country requires cohesive support from both the government and various social institutions. Currently, with initiatives like the 'Make in India' Innovation Mission, there is a strong emphasis on fostering innovation and manufacturing right from the school level. This presents an opportune moment for India to adapt and cultivate a culture of practical, application-based learning and advancement across schools, students, universities, and educators. To ensure the sustained success of initiatives like 'Make in India,' it is imperative to recognize that more than just financial investment is needed. A well-educated and skilled population capable of contributing to advanced industries is essential. Thus, India must focus on equipping its citizens with the necessary education and expertise required for modern, high-tech sectors.

Luckily, there are gatherings of business people, instructors, and trend-setters who hear the call uproarious and clear and are putting resources into STEM schooling to foster local ability.

4. OBJECTIVES OF THE STUDY

1. To identify the factors responsible for the cognitive development of students at middle school level.

2. To analyse the effect of STEM based education on the cognitive development of student at middle school level.

3. To compare the academic progress of student using STEM based education and the traditional methods of education.

4. To develop a framework for the best practices of STEM based education at middle school level.

5. METHODOLOGY

5.1. Research Design

In this study, both exploratory, as well as a descriptive research technique, will be used to gain the information & awareness of STEM implementation in educational organizations. Both secondary as well as primary data, will be used to conduct exploratory research.

5.2. Data Collection

Primary data shall be collected through a structured questionnaire. The on-line survey research method will be used to collect the data for cross-sectional analysis at a faster rate. The exploratory research approach will be used for primary data collection through a multi-level case study (observation, analysis of the documents, and conducting interviews).

Secondary data shall be collected from the Literature Review, by collecting data from published journal articles, review papers, research work, magazines, etc.

5.3. Questionnaire

Based on our objectives, questionnaire will be developed to assess the cognitive level of STEM learners & non-STEM learners. Each participant will be informed regarding the study and

those who are willing to participate will fill the questionnaire.

5.4. Sample Selection

Multi-stage stratified random sampling and convenient sampling techniques will be used to collect the samples. The study will not be limited to a particular school but will be targeted to many educational organizations opting STEM education in India by an online survey. However, the majority of work shall be carried out in the National Capital Territory of Delhi. The sample size would be 500 students.

6. EXPECTED OUTCOME OF THE RESEARCH

1.The examination shows that there is potential in STEM training for cognitive development and assists with creating intellectual and emotional angles identified with STEM past content alone.

2. Learning is the beginning stage of intellectual turn of events. The learning happens when the students get the data in their short transient memory and practice the data in the functioning memory with the goal that it will proceed to be put away in the long-haul memory. Students foster their abilities while solving real life problems with four disciplines (STEM) and they turned out to store in their minds what they have learned through STEM.

3.The correct opportunity has arrived when STEM training should be carried out by every single school in the country.

4. Our up-and-coming age of kids is exceptionally honoured to be brought into the world in this advanced 21st century where STEM is need of an hour as coming ages would love to collaborate with innovation and they spend innumerable hours utilizing it.

5. Subsequently, it is the duty of guardians and educators to rouse and spread mindfulness about STEM training in India.

6. Results showed that early openness to STEM educational plan prompts an expansion in the intellectual credits, particularly those connected spatial representation and mental turn.

7. Parts of the STEM classes which incorporate three-dimensional models, design or robot building make changes in these intellectual credits. Hypotheses and concentrates thus demonstrate that openness to STEM schooling contributes towards the sound advancement of cognition in kids.

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by Neetu Kaur

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SHORT SYNOPSIS

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MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH & STUDIES

ABSTRACT

Cognitive Development derives how individuals think, explore and sort out the things. It is the progress of information, limits, essential thinking and mindsets, which assist individual with considering and understanding their generally natural components. Passionate prosperity is central for insightful new turn of events. Like the sort of information being found about the working of memory, teaching best for innovativeness, and the way individuals learn. Science, Technology, Engineering and Math (STEM) is latest and testing change of preparing which helps in making 21st century limits and innovative thinking. The reason for this investigation is to assess the causal impact of the STEM (Science, Technology Engineering, Mathematics) drive on middle school students' psychological results. Middle school is a significant momentary time during students' lives. During middle school, students are all more truly thinking about their scholastic and non-scholarly interests, just as future school and vocation

plans. The greater part of the STEM training research centres around rudimentary or secondary schools, and hardly any investigations centre explicitly around the impact of a STEM informative structure on the results of middle school students. Given growing interest for versatile geniuses prepared in the STEM fields it is significant that we understand that STEM drive have effective impact on middle school level student as at this stage the cognitive development is high and this can be done with proper training and practical exposure of concepts rather than giving them habit of cramming just to clear the exam. STEM will be a quality tool to flourish the capacity of young minds and at this level, they adapt information which would be long lasting throughout their life so this requirement can be fulfil through STEM Education. This shows that there is much scope in STEM which boosts cognitive development and assists students with making academic and higher request thinking abilities.

Keywords: Cognitive Skills, Learning, STEM, Thinking Ability, Assessment, Creativity, Interdisciplinary STEM.

Examine the Impact of STEM Education on the Cognitive Advancement of Middle School Students

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